Farmers' adaptation to climate change: Evidence from Vietnamese rural households

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1. Introduction

Natural disasters and their adverse impacts on agriculture are expected to be exacerbated by climate change in Vietnam. However, the size and nature of these impacts depend on the ability of farmers to adapt. Empirical economic studies have focused on the impacts of temperature and precipitation on agricultural outputs to assess farmers' adaptive capability. Burke and Emerick (2016) recently compared the long- and short-term adaptation using both the long-difference approach and the panel analysis. Empirical evidence on specific agricultural practices for climate change adaptation is limited to land allocation, crop choice, and irrigation (Kurukulasuriya and Mendelsohn, 2008; Kurukulasuriya and Mendelsohn, 2011; etc.). These studies mainly apply the cross-sectional method, which is criticized for the omitted variable bias. Kurukulasuriya and Mendelsohn (2011) attempted to address this problem by building a two-stage selection model in the Ricardian framework, while a few recent studies employed fixed effects models (Ponce, 2020, etc.). Still, the number of panel studies as well as adaptation practices they analyzed is small. Previous literature also lacks evidence on how the adjustment in farm management to weather fluctuations is likely to change from the short to the long run and how it differs from adjustment to disaster experience.

Besides, many studies find that the farmer's adaptation capacity is determined by age and experience. Given that aging of the farming population arises in Vietnam and many developing nations, it is important to fully perceive the role of this factor in farmers' future adaptation capacity.

2. Methodology and Data

This study will examine how farmers adjust their agricultural management practices in response to natural disasters and weather variations. We contribute a comprehensive analysis of practices that were not considered in previous literature. In addition, we assess the effect of age on their adaptive capability. Data in this study mainly come from the Viet Nam Access to Resources Household Survey (VARHS) for the 2010-16 period, which collects information about the lives of rural households every two years in 12 provinces in Vietnam. We use the sub-sample of crop-producing households, which account for approximately 82 percent of the total sample (N= 6,553).

Our approach uses monthly weather to create temperature and precipitation bins, that is, the number of months in a year that temperature or precipitation falls into a defined group of temperature or precipitation. Also, we allow weather shocks to have both short- and long-term impacts on adaptive behaviors by including their one, two, and three-year lags in our identification. We capture past exposure to natural disasters by defining an indicator variable for whether households self-reportedly experienced disasters (e.g., flood, drought, typhoon, landslide, frost, etc.) that hit their farmland in the past two years or not. Based on a fixed-effects model, our main specification is as follows:

$$Y_{i,t} = \alpha dis_{i,t-2} + \sum_{n=1}^{3}\sum_{j=1}^{5}\beta_{j,n} temp_{j,t-n} + \sum_{n=1}^{3}\sum_{j=1}^{5}\gamma_{j,n} precip_{j,t-n} + \delta X'_{i,t} + \mu_i + \tau_{t,d} + \varepsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ is the adaptive practices that household *i* adopted in year *t*, including irrigation, physical infrastructure for soil and water conservation (e.g., stone bunds, soil bunds/grass lines, terraces, etc.), annual crop rotation, crop diversity, agroforestry, and integrated crop-livestock systems; $dis_{i,t}$ is a dummy variable for past exposure to natural disasters; $temp_{j,t-n}$ and $precip_{j,t-n}$ are the lags of weather bin variables as explained above; $X'_{i,t}$ is a vector of background characteristics; $\tau_{t,d}$ captures time effect by district. To capture the impact of age on the adoption of adaptive measures, we augment equation (1) with the cross terms of disasters experience/ weather variables and household head's age groups (18-29, 30-39, 40-49, 50-59, and over 60).

3. Results and Conclusion

Table 1 presents our preliminary estimation results. Firstly, exposure to disasters in the past two years is associated with a higher likelihood of applying physical infrastructure for soil and water conservation, annual crop rotation, crop diversity, and agroforestry by 3.5, 4.5, 3.1, and 2.7 percent, respectively. However, the uptake of crop-livestock systems is not significantly affected by past disaster experience. In contrast, results confirm that farmers are less likely to irrigate after a disaster. Irrigation is usually an adaptive measure to heat and water scarcity. Natural catastrophes such as floods, typhoons, or landslides can damage irrigation infrastructure. Hence, farmers are unwilling to take this measure since the return on investment in irrigation facilities will be small.

Secondly, we find some evidence of the nonlinear relationship between weather shocks and farmers' adaptive behaviors. Estimation results show a U-shaped relationship between temperature and irrigation/physical infrastructure for soil and water conservation but an inverse U-shaped relationship between temperature and crop-livestock systems/ crop diversity. For example, when the temperature one year ago is very low (15-20°C) or high (over 25°C), farmers are more

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likely to apply soil and water conservation practices (e.g., irrigation, stone bunds, etc.) but less likely to adopt the crop-livestock systems than when the temperature is moderate (20-23°C). However, when considering the temperature three years ago, farmers are not willing to diversify crops at these extreme levels.

In addition, our results indicate a consistent U-shaped relationship between precipitation and all adaptation practices, except the crop-livestock systems. Specifically, farmers respond to extremely low (0-25mm or 25-50mm) and high precipitation (over 300mm) in the past year by increasing crop rotation and agroforestry application. When rainfall is too scarce (0-25mm) or excessive (200-300mm or over 300mm) in the last two and three years, they are more likely to adopt soil and water conservation measures, crop diversity, and agroforestry. Overall, our findings suggest that farmers adapt to extreme weather shocks by adjusting the use of adaptive agriculture practices in both the short and long run.

Thirdly, we find that aging significantly impacts the application of adaptation technologies (estimation results are not reported here due to space limitations). When a disaster occurs, older farmers are more likely to take irrigation/ crop-livestock systems but less likely to apply agroforestry than younger farmers under 30. In response to weather variations, older farmers are less willing to adopt irrigation when rainfall in the past one or two years is scarce (0-50mm) and the crop-livestock systems when rainfall in the longer term is too excessive (over 300mm). These farmers are also less likely to rotate crops when facing high temperatures (over 23°C) three years ago. These findings suggest that aging significantly reduces farmers' adaptation capacity.

Table 1. Effects of disaster experience and weather shocks on the adoption of farm management practices

Dependent Vars	Irrigation	Physical Infrastructure	Crop rotation	Crop diversity	Agroforestry	Crop-livestock systems
Disaster	-0.017*	0.035**	0.045***	0.031*	0.027*	0.019
Temp lag 1: < 15 (Base: 20-23)	-0.042	-0.663**	0.330	-1.397***	-0.374	0.139
15-20	0.240***	1.022***	-0.096	0.072	0.124	-0.295**
23-25	0.172**	0.405***	-0.046	0.266**	0.030	-0.330***
> 25	0.195*	0.158*	0.074	0.161	0.309**	-0.389**
Temp lag 2: < 15 (Base: 20-23)	-0.156*	0.515***	-0.186**	0.347**	0.451**	0.128
15-20	0.004	0.533***	-0.283**	0.613***	0.376*	0.097
23-25	-0.064	-0.333**	0.198***	-0.523***	-0.115	0.183
> 25	0.086	0.384**	0.090	-0.222**	-0.395*	-0.137
Temp lag 3: < 15 (Base: 20-23)	0.111	0.287***	-0.053	-0.467***	0.011	0.135
15-20	-0.064	0.325***	-0.028	0.002	0.317*	0.114
23-25	-0.198*	-0.302***	0.071	-0.476***	-0.273**	0.192
> 25	-0.452**	-0.121	0.124	-0.733***	-0.696**	0.189
Precip lag 1: < 25 (Base: 50-200)	0.001	-0.327*	0.138	0.725***	0.357*	-0.192
25-50	0.031	-0.528***	0.229***	0.115	0.060	-0.108
200-300	-0.089*	0.012	0.051	0.112	0.212**	0.088
> 300	-0.015	0.060	0.108**	0.105	0.265**	0.058
Precip lag 2: < 25 (Base: 50-200)	-0.009	-0.023	0.107	0.274**	0.412**	0.127
25-50	-0.113*	-0.031	0.028	-0.169***	0.170	0.177*
200-300	-0.051	-0.064	0.122**	0.378***	0.305**	-0.124
> 300	0.164	-0.133	0.047	0.501***	0.223	-0.328*
Precip lag 3: < 25 (Base: 50-200)	0.475*	0.857***	-0.342	0.665**	0.480	-0.333
25-50	0.213***	0.228***	-0.073	-0.100	0.118	-0.017
200-300	0.109*	0.241***	-0.046	0.092	0.025	-0.033
> 300	-0.031	-0.084	0.061	-0.054	-0.033	0.033
Observations	6,553	6,553	6,553	6,553	6,553	6,553
R-squared	0.244	0.527	0.334	0.232	0.182	0.158

Notes: ***, ** and * indicate 1%, 5% and 10% significant levels.

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